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(71) Applicant
American Cyanamid Company, Berdan Avenue, Township of Wayne, State of New Jersey, United States of America
(72) Inventors
Michael Thomas Beachem,
Mary Louise Vega,
William Robert Heffernan,
Joel Anthony Gingras,
Edward Thornton Rockwell
(74) Agent
Tregear, Thiemann & Bleach

(54) Chemiluminescent Device

(57) The device comprises a flexible translucent tube 2, a frangible vial 5 containing a solution of a bis(carbalkoxy-trichlorophenyl)oxalate wherein alkoxy has 1 to 8 carbon atoms and a 9,10 bis(phenylethynyl) anthracene, preferably in a diluent e.g. dibuty phthalate, and a second frangible vial 4 containing hydrogen and sodium salicylate in dimethyl phthalate and *t*-butanol peroxide, the tube containing dibutyl phthalate as a diluent for said components and optionally an additional amount of an anthracene. Other peroxides and diluents together with specific oxalates, anthracenes and solvents are given. Embodiments of the device are described which include a lever for breaking the vials (Figures 2 and 7 to 8 not shown) and an arrangement for storing and displaying the device (Figures 3 to 6 not shown).

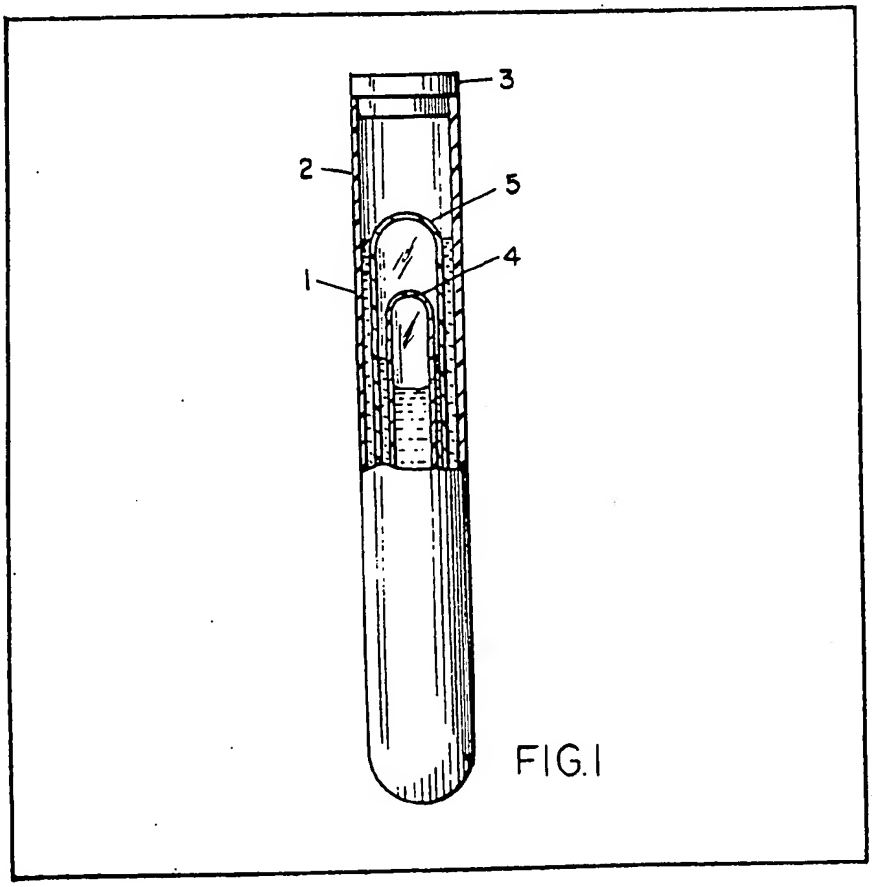

FIG.1

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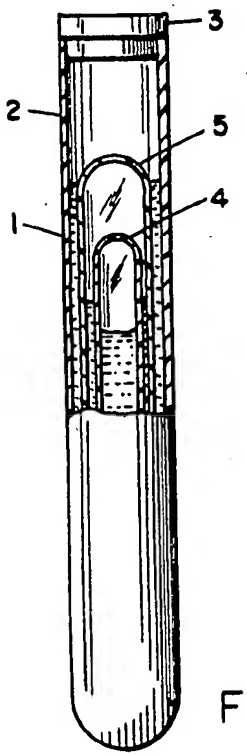

FIG.1

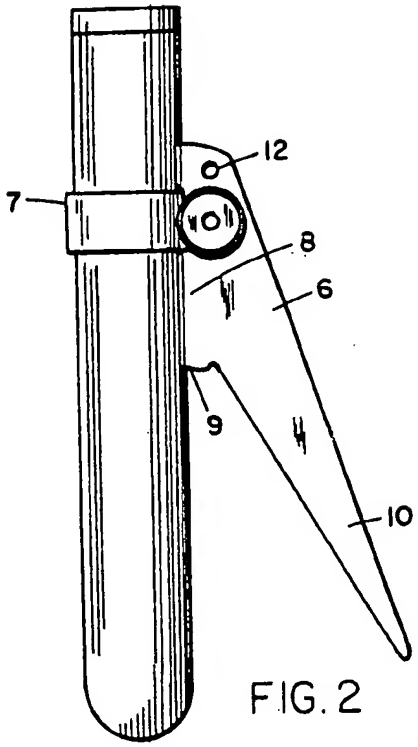

FIG. 2

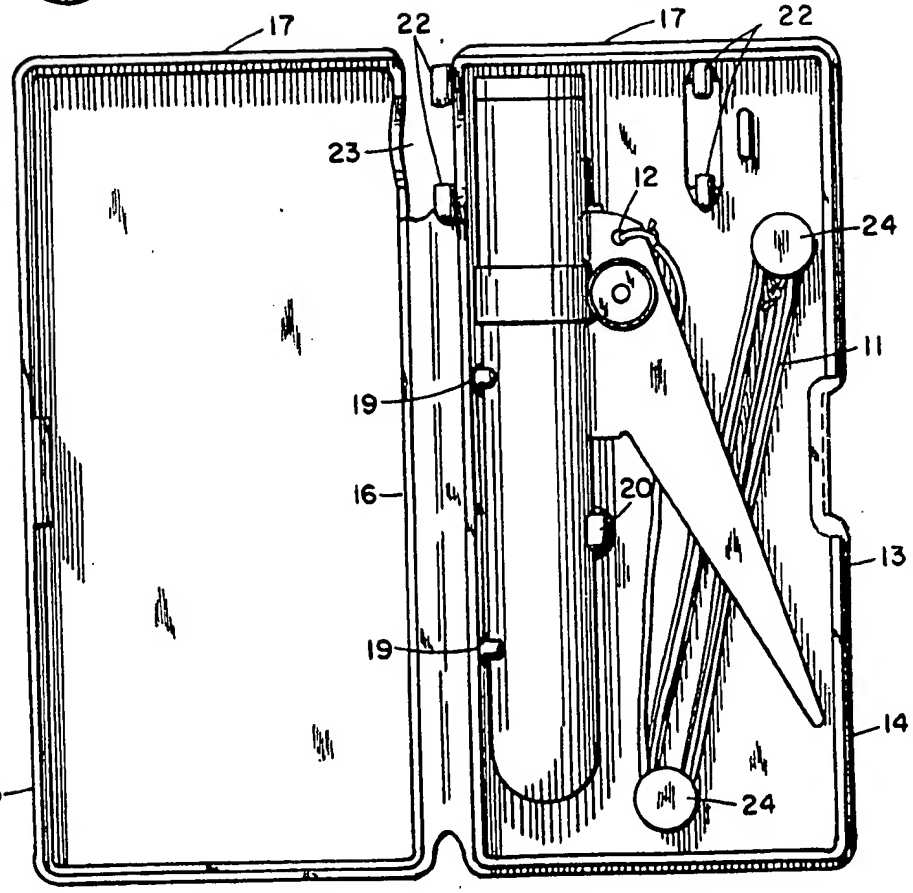

FIG. 3

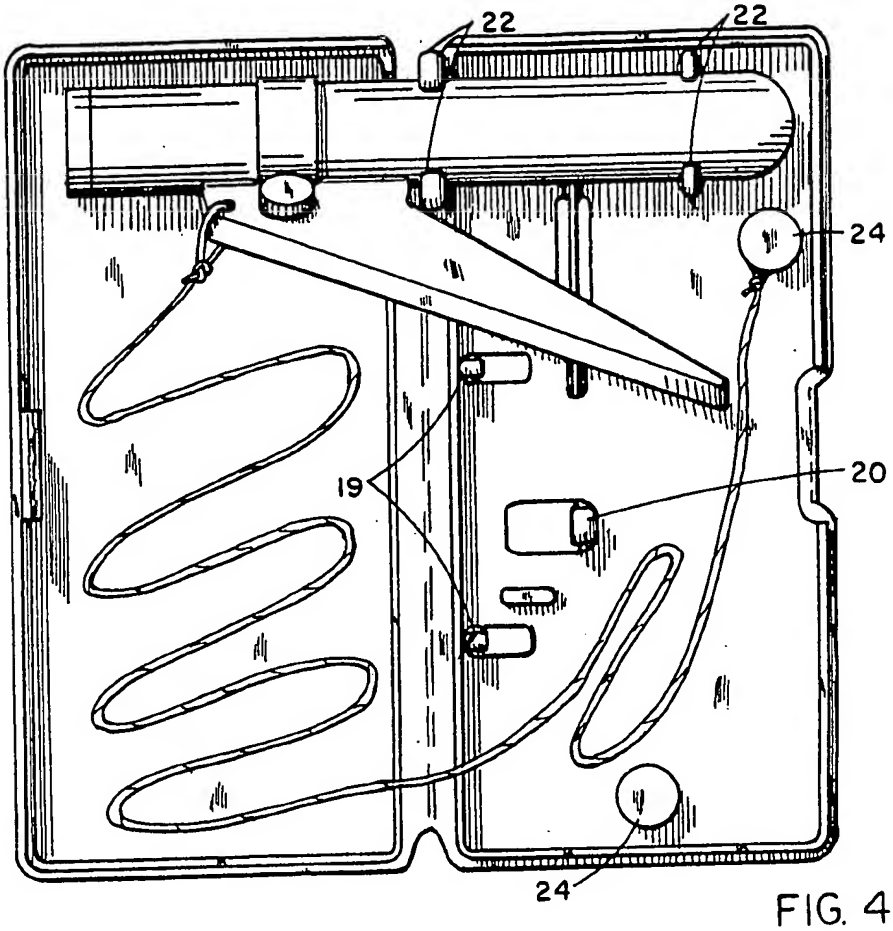

FIG. 4

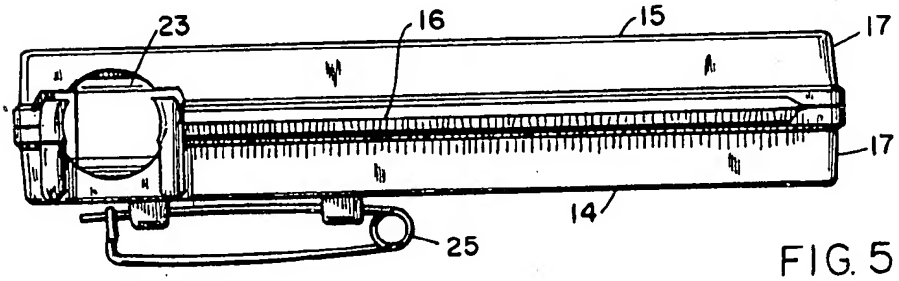

FIG. 5

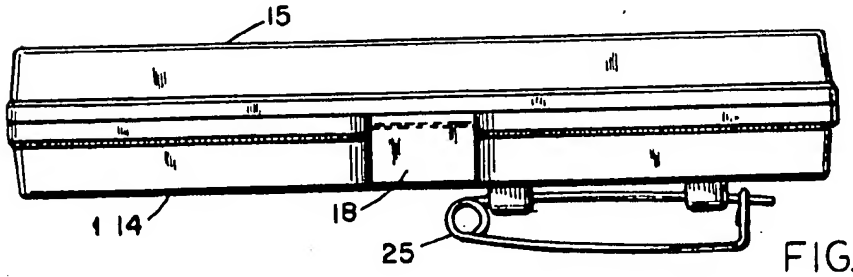

FIG. 6

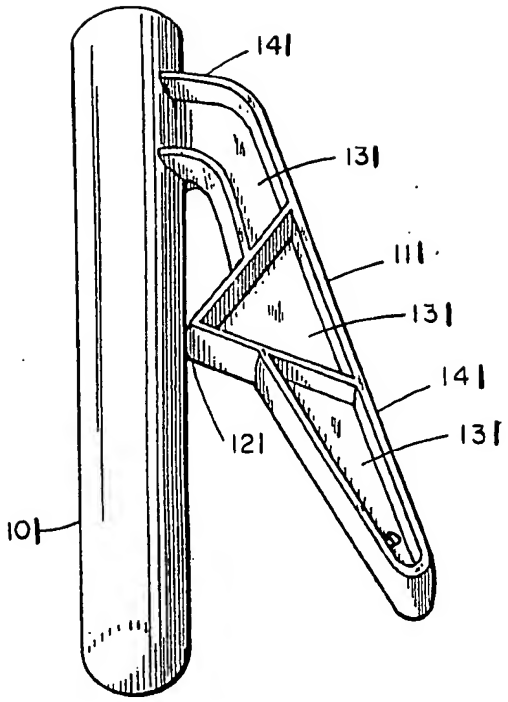

FIG. 7

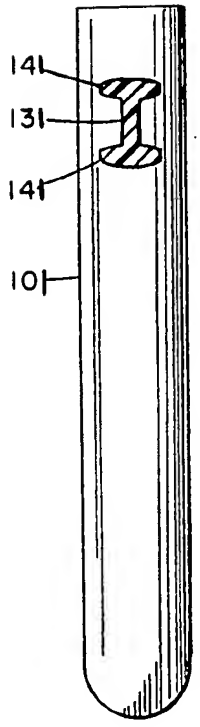

FIG. 8

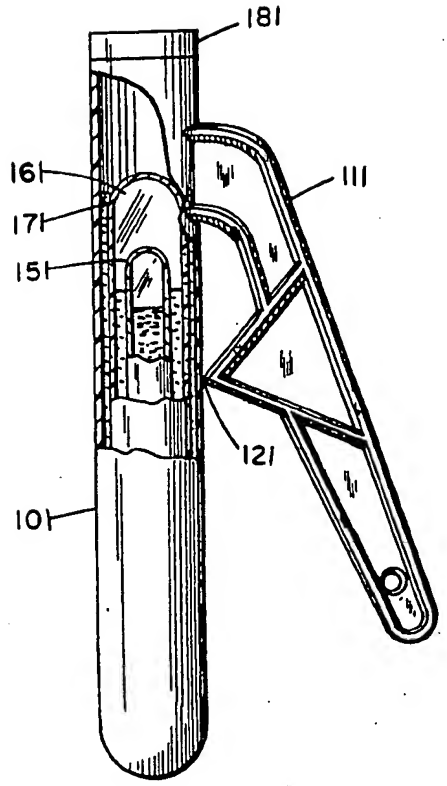

FIG. 9

SPECIFICATION
Lightstick

The invention relates to a chemiluminescent lightstick and to an emergency lighting device which comprises the chemiluminescent lightstick.

The utility of chemiluminescent lightsticks in emergency situations is known. Several lightsticks have been described which are suitable for such use. Essentially a chemiluminescent lightstick comprises a flexible, translucent outer tube which encloses several chemical components of a chemiluminescent mixture with frangible means separating those components within the outer tube. When the frangible separating means is broken, the components combine within the outer tube and react to produce chemical light. Typically, a lightstick would comprise a flexible polyethylene outer tube sealed at both ends and one or two inner glass vials, each vial containing separate components of the chemiluminescent mixture. While the components are separated by the intact vials within the outer tube they are practically inert and will not produce light. When the inner vials are broken by actuation of the flexible outer tube, the components are mixed within the outer tube and the mixture of reactants produces chemiluminescent light. This reaction produces light without emission of heat, flame, sparks or gases, hence the lightstick is safe for lighting in explosive environments, and can be used without danger of causing fire or of burning the user. The reaction is contained entirely within the outer tube so the light will not be extinguished by contact of the lightstick with water; the lightstick can even be used while submerged in water. Certain lightsticks can emit light of considerable intensity for several hours after actuation, so they can be used as markers for rescue operations at night.

The lightstick in accordance with the present invention comprises a flexible, light-transmitting, outer tube, and contained therein first and second frangible, preferably glass, vials, the first vial containing a solution of a bis(carbalkoxytrichlorophenyl)-oxalate, wherein the alkoxy group has 1 to 8 carbon atoms, and a 9, 10-bis(phenylethynyl)anthracene component in a suitable diluent, as a first component, said second vial containing a peroxide component and the outer tube containing outside said vials a diluent for said components, or a solution of a 9,10-bis(phenylethynyl)-anthracene compound in a diluent, as a third component. The outer tube is sealed with a closure means.

Surprisingly, it has been found that by reducing the concentration of the bis(carbalkoxy-trichlorophenyl)oxalate about 25 to 40% below that used in conventional devices improved emission of light can be obtained. This reduction is accomplished by means of the third component.

Preferably, the system and device comprises a relatively concentrated solution of a bis(6-carbalkoxy-2,4,5-trichlorophenyl)oxlate, wherein the alkoxy group has 5 to 8 carbon atoms, and 9,10-bis(phenylethylnyl)anthracene or a halo-substituted 9,10-bis(phenylethynyl)anthracene in a diluent, as the first component; a solution of hydrogen peroxide and an accelerator in a diluent, as the peroxide component; and a solution of 9,10-bis(phenylethynyl)anthracene or a halo-substituted 9,10-bis(phenylethynyl)anthracene in a diluent as the third component.

More preferably, the system and device comprises a solution of bis(6-carbopentoxy-2,4,5-trichlorophenyl)-oxalate and 9,10-bis(phenylethynyl)anthracene or monochloro-9,10-bis(phenylethynyl)anthracene in dibutyl phthalate, as the first component; a solution of hydrogen peroxide and sodium salicylate in a mixture of dimethyl phthalate and tertiary butanol, as the second component; and a solution of 9,10-bis(phenylethynyl)-anthracene or a monochloro-9,10-bis(phenylethynyl)-anthracene in dibutyl phthalate, as the third component.

The advantage of the improved system and device of this invention in preferred embodiments are as follows:

1. The system and device employed herein allows the volume of chemiluminescent composition to be increased by about 40 to 70% over the volume of chemiluminescent composition in a conventional device.

2. The sealing of the oxalate ester in the inner tube means protects it from hydrolysis.

3. The use of a diluent, or a solution of the fluorescer compound in a diluent, as the third component provides protection against accidental activation of the device by impact.

Description of Preferred Embodiments

Illustrative of the preferred bis(carbalkoxy-trichlorophenyl)oxalates which can be used in this invention are the following:

bis(6-carbopentoxyphenyl-2,4,5-trichlorophenyl)oxalate,
bis(6-carboctyloxyphenyl-2,4,5-trichlorophenyl)oxalate,
bis(6-carbomethoxyphenyl-2,4,5-trichlorophenyl)oxalate,
bis(6-carbopentoxyphenyl-2,3,5-trichlorophenyl)oxalate,
bis(6-carboctyloxyphenyl-2,3,5-trichlorophenyl)oxalate,
and the like.

The concentration of the oxalate in the first component may range from about 0.025M to about 3.65M. More preferably, the concentration ranges from about 0.07M to about 0.7M.

The fluorescer compounds contemplated herein may be defined as 9,10-bis(phenylethynyl)anthracene, or chloro, bromo, fluoro, or lower alkyl-substituted bis(phenylethynyl)anthracenes. The preferred fluorescer compound is selected from 9,10-bis(phenylethynyl)anthracene or chloro-substituted 9,10-bis(phenylethynyl)anthracenes. More preferably the fluorescer compound is

selected from 9,10-bis(phenylethynyl)anthracene, 1-chloro-9,10-bis(phenylethynyl)anthracene, or 2,-chloro-9,10-bis(phenylethynyl)anthracene.

Illustrative of the preferred 9,10-bis(phenylethynyl)anthracenes which can be used in this invention are the following:

9,10-bis(phenylethynyl)anthracene,
1-chloro-9,10-bis(phenylethynyl)anthracene,
2-chloro-9,10-bis(phenylethynyl)anthracene,
1,5-dichloro-9,10-bis(phenylethynyl)anthracene,
1,8-dichloro-9,10-bis(phenylethynyl)anthracene,
1-bromo-9,10-bis(phenylethynyl)anthracene,
1-fluoro-9,10-bis(phenylethynyl)anthracene,
1-methyl-9,10-bis(phenylethynyl)anthracene,
and the like.

The concentration of the 9,10-bis(phenylethynyl)anthracene compound in the first and third components of this invention may range from about 0.0002M to about 0.03M. More preferably, the concentration ranges from about 0.001M to about 0.010M.

If the 9,10-bis(phenylethynyl)anthracene compound has sufficient solubility in the first component, all of the fluorescer compound may be incorporated in the first component and a pure diluent used as the third component. In such a situation the concentration of 9,10-bis(phenylethynyl)anthracene compound in the first component may range from about 0.0004M to about 0.06M. Preferably, the concentration ranges from about 0.002M to about 0.02M. The fluorescer compounds 1 and 2-chloro-9,10-bis(phenylethynyl)anthracene can be used in such a manner.

Although different fluorescer compounds may be used in the first and third components, if desired, it is preferable to use the same compound.

The diluents which are used in the components of this invention must be present in sufficient amounts to form at least a partial solution of the reactants involved in the chemiluminescent reaction. Any fluid diluent can be employed in the first and third components providing said diluent solubilizes the bis(carbalkoxy-trichlorophenyl)oxalate and 9,10-bis(phenylethynyl)anthracene compound to provide the desired concentrations and is non-reactive toward these materials. Typical diluents, or solvents, which can be used include esters, ethers, aromatic hydrocarbons, chlorinated aliphatic and aromatic hydrocarbons such as those disclosed in U.S. Patent No. 3,749,679. The preferred diluent is dibutyl phthalate. Solvent combinations may, of course, be used but such combinations should not include strongly electron donating solvents.

The peroxide component used as the second component may be any peroxide, hydroperoxide, or hydrogen peroxide compound. Typical hydroperoxides include t-butylhydroperoxide, peroxybenzoic acid, and hydrogen peroxide. Hydrogen peroxide is the preferred hydroperoxide and may be employed as a solution of hydrogen peroxide in a solvent or as an anhydrous hydrogen peroxide compound such as perhydrate of urea (urea peroxide), sodium perborate, sodium peroxide, and the like. Whenever hydrogen peroxide is contemplated to be employed, any suitable compound may be substituted which will produce hydrogen peroxide.

Diluents which can be employed in the peroxide component include any fluid which is relatively unreactive toward the hydroperoxide, the chemiluminescent compound, and the fluorescer compound, and which accommodates a solubility to provide at least 0.01M hydroperoxide. Typical solvents for the hydroperoxide component include water; alcohols, such as ethanol, tertiary butanol, or octanol; ethers, such as diethyl ether, diamyl ether, tetrahydrofuran, dioxane, dibutyldiethyleneglycol, perfluoropropyl ether, and 1,2-dimethoxyethane; and esters, such as ethyl acetate, ethyl benzoate, dimethyl phthalate, dioctylphthalate, propyl formate. Solvent combinations can, of course, be used such as combinations of the above with anisole, tetraline, and polychlorobiphenyls, providing said solvent combination accommodates hydroperoxide solubility. However, strong electron donor solvents such as dimethyl formamide, dimethyl sulfoxide, and hexamethylphosphoramide should not, in general, be used as a major diluent for the peroxide component.

The preferred diluent for the peroxide component is a mixture of about 80 volume dimethyl phthalate and about 20 volume percent tertiary butanol.

The hydrogen peroxide concentration in the peroxide component may range from about 0.05M to about 15M. Preferably, the concentration ranges from about 1M to about 2M.

The lifetime and the intensity of the chemiluminscent light obtained with the preferred bis(6-carbalkoxy-2,4,5-trichlorophenyl)oxalates and hydroperoxide can be regulated by the use of certain regulators such as:

(1) By the addition of a catalyst which changes the rate of reaction of hydroperoxide with the oxlate ester. Catalysts which accomplish that objective include those described in M. L. Bender, "Chem. Revs.", Vol. 60, p. 53 (1960). Also, catalysts which alter the rate of reaction or the rate of chemilumcence include those accelerators of U.S. Patent No. 3,775,366.

(2) By the variation of hydroperoxide. Both the type and the concentration of hydroperoxide are critical for the purposes of regulation.

(3) By the addition of water.

Preferably, a weekly basic accelerator, such as sodium salicylate, is included in the peroxide component to control the lifetime of the chemical lighting system. The concentration of weekly basic accelerator used in the peroxide component may range from about 10^{-5}M to about 10^{-2}M, preferably from about 10^{-4}M to about 10^{-3}M. Optionally the weak base may be incorporated as a separate component if desired.

The ratio of the total volume of first and third components to peroxide component preferably ranges from about 2.5 to about 5.5. and is more preferably about 4.0 to about 5.0. The total volume of the three components is preferably such that upon activation of the device the initial concentration of bis(carbalkoxy-trichlorophenyl)oxlate in the resulting chemiluminescent mixture ranges from about 0.05M to about 0.09M.

Similarly, within the scope of the present invention is the concurrent employment of one or more decelerators either along or in conjunction with one or more of the accelerators discussed in the preceding paragraphs. By employing one of the accelerators of the preceding paragraph, it would be possible to employ a greater total concentration of the oxalate while concurrently it would be possible to employ a decelerator which would prolong the period during which the light of high intensity is obtained from the chemiluminescent reaction. Such decelerators set forth in U.S. Patent Nos. 3,691,085 and 3,704,231 include, for example, a compound such as oxalic acid.

A preferred embodiment of the invention will be described in more detail by reference to the drawings, wherein:

Figure 1 is a sketch of the lightstick that is most preferred for use in accordance with the invention, showing the several parts intact, as they are before the lightstick is actuated to produce light;

Figure 2 is a sketch of the lightstick with an attached actuating device;

Figure 3 is a top view of the container opened to show the lightstick and actuating device clamped at storage position inside the box;

Figure 4 is another top view of the open container showing the lightstick clamped at its display position;

Figure 5 is a rear view of the container with its lid closed, showing the hinge which joins the lid to the box and showing an aperture which is provided in the rear walls for fitting the lightstick in its display position; and

Figure 6 is a front view of the closed container showing the latch for holding the lid shut.

Referring to Figure 1, the lightstick (1) comprises a translucent, flexible outer tube (2) closed at one end and having an opening at its other end through which the contents of the lightstick are inserted, and in which a plug (3) is inserted and sealed to retain the contents within the outer tube. Inside the tube are two glass vials, 4 and 5 each containing a separate liquid component of the chemiluminescent mixture.

In the embodiment shown in the drawing, one of the glass vials is contained within the other. The inner glass vial (4) is about 85 mm. long, 7.5 mm. outside diameter, 0.2 mm. wall thickness and is partially filled with 2.5 ml. of a solution made from hydrogen peroxide and 0.1 gm. of sodium salicylate in 773 ml. dimethylphathalate and 212 ml. tert-butanol. The outer glass vial (5) is 12.48 mm. outer diameter, 0.4 mm. wall thickness and of a length to fit within the outer tube and to contain the sealed inner tube and also to contain 6 ml. of a solution made from 135.1 gm. bis-6(carbopentoxy-2,4,5-trichlorophenyl)oxalate 1.113 gm. of 9,10-bis(phenylethynyl)anthracene and enough dibutylphthalate to make one liter. The outer tube (2) is a molded polyethylene cylindrical tube closed at one end and open at the other. It is about 18 mm. in diameter, has wall thickness about 1.4 mm. and is about 130 mm. long. In addition to the glass vials with their contents, the outer tube also contains 5 ml. of a solution made with 1.13 grams of 9,10-bis(phenylethynyl)-anthracene and enough dibutylphthalate to make one liter of solution. A polyethylene plug (3) is inserted and sealed in the open end of the outer tube to contain all of the contents within the tube.

To activate the device and provide chemiluminescence, tube 1 is flexed slightly, breaking the tubes and allowing the contents to admix with the third component 9 and emit chemiluminescence.

The color of the light emitted will depend on the particular fluorescer compound used and its spectral response. However, the visible color can also be varied by using a colored plastic for tube 1.

Additional tubes may be placed inside tube 1, if desired, to incorporate reaction rate regulators and to provide optimum storage conditions by separating these materials from the other reaction components.

If desired a parabolic reflective member may be used in conjunction with the activated device to intensify the light in a particular direction.

The invention provides an improved device for providing visible light whenever and wherever desired, independent of conventional electrical lighting methods and without the hazards and limitations of electrical lighting. The chemiluminescent lighting systems can be especially useful in emergency situations where all other forms of lighting have failed. The systems do not have the fire of ignitable lighting devices such as candles, gas, or oil lights.

It will be readily apparent that the chemiluminescent device is not confined to emergency lighting, however. It can be used at any time where a cold, safe illuminating means is desired. It is also useful to provide illumination where electrical illumination is unavailable. The device is highly portable and can be hand-held for signalling.

Example 1

Preparation of First Component

A. The first component is prepared by dissolving 135.1 grams (0.199 mole) of bis(6-carbopentoxy-2,4,5-trichlorophenyl)oxlate (see Example XXVI of U.S. Patent No. 3,749,679) in 800 mls of high quality dibutyl phthalate and heating the solution at 150°C under nitrogen for

one hour. The solution is cooled under nitrogen to 80—90°C and 1.113 grams (0.003 mole) of 9,19-bis(phenylethynyl)anthracene (see Example XXXVIII of U.S. Patent No. 3,557,223) are added thereto. The mixture is cooled to room temperature and diluted to a total volume of 1 liter by adding dibutyl phthalate thereto.

B. The procedure of Example 1A is followed except that 180 grams (0.266 mole) of bis(6-carbopentoxy-2,4,5-trichlorophenyl)oxlate are used.

Example 2

The procedure of Example 1A is followed utilizing 115.1 grams (0.170 mole) of bis(6-carbopentoxy-2,3,5 tri-chlorphenyl)oxlate and substituting 2.065 grams (0.005 mole) of 2-chloro-9,10-bis(phenylethynyl)anthracene for the 9,10-bis(phenylethynyl)anthracene.

Example 3

The procedure of Example 1A is followed utilizing 135.4 grams (0.20 mole) of bis(6-carbopentoxy-2,4,5-trichlorophenyl)oxlate and substituting 3.83 grams (0.009 mole) of 1-chloro-9,10-bis(phenylethynyl)anthracene for the 9,10-bis(phenylethynyl)anthracene.

Example 4
Preparation of Peroxide Component

A mixture of 773 mls of dimethyl phthalate, 212 mls of tertiary butanol and 0.10 gram (0.000625 mole) of sodium salicylate is stirred at room temperature to obtain a clear solution. Fifty three grams (1.52 moles) of hydrogen peroxide (98%) are weighed in an open beaker and slowly added to the stirred mixture. The solution is then stirred at room temperature for one hour and transferred to a polyethylene container.

Example 5
Preparation of Third Component

1.113 grams (0.003 mole) of 9,10-bis(phenylethynyl)anthracene are dissolved in 800 mls of dry dibutyl phthalate at 80—90°C. The solution is then cooled to room temperature and made up to a total volume of 1 liter by adding dry dibutyl phthalate thereto.

Example 6

The procedure of Example 5 is used substituting 2.065 grams (0.005 mole) of 2-chloro-9,10-bis(phenylethynyl)anthracene for the 9,10-bis(phenylethynyl)anthracene.

Example 7

The procedure of Example 5 is used substituting 3.83 grams (0.009 mole) of 1-chloro-9,10-bis(phenylethynyl)anthracene for the 9,10-bis(phenylethynyl)anthracene.

Example 8
Preparation of the Devices

A. A cylindrical glass tube (0.2 mm.±0.04 mm. wall thickness, and 12.48 mm.±0.01 mm. outer diameter), having one end closed, is charged with 6.0 mls. of the oxalate component of Example 1A.

The sealed tube containing the peroxide component is inserted inside the larger tube and the open end of the larger tube is sealed in a flame to form a concentric pair of tubes, one tube sealed within the other. The overall length of the sealed outer glass tube is about 115 mm.

5.0 mls. of the solution of Example 5 are added to the inside of a molded cylindrical polyethylene tube which is closed at one end. The polyethylene tube has an outside diameter of about 18.0 mm., a wall thickness of about 1.40 mm. and an overall length of about 140 mm. The concentrically sealed pair of glass tubes is inserted in the polyethylene tube and a polyethylene plug is inserted in the open end and heat sealed to the polyethylene tube. The overall length of the sealed polyethylene tube is about 130 mm.

B. The procedure of Example 8A is followed utilizing 6.0 mls. of the oxalate composition of Example 1B as the first component.

The devices of Examples 8A and 8B upon bending and shaking well emit a yellowish-green light. The intensities of the emitted light are reported below in Table I as luminosity values (lumens per liter) as measured by means of a broadband photometer versus time at 27.5°C.

Table I
Luminosity (lumens per liter)

Device	0 Min.	10 Min.	30 Min.	60 Min.
A	1400	198	149	65
A	1380	194	146	65
A	1375	200	156	73
B	1660	140	124	66
B	1280	163	134	67
B	1430	158	136	78

The concentration of bis(6-carbopentoxy-2,4,5-trichlorophenyl)oxalate obtained immediately after activating the devices from Examples 8A and B are about 0.088M and 0.118M, respectively. These results show the lower early intensities obtained with Device B in which the oxalate concentration in the activated device is higher.

For convenience in actuating the lightstick when light is needed, the lightstick in one embodiment is provided with an attached actuating device, which provides lever and fulcrum means by which one can conveniently bend the outer tube and thereby break the inner vials. One can conveniently bend the outer tube against the fulcrum by squeezing the tube and lever together using the palm and fingers of one hand to actuate lightstick. A convenient device for this use has been described in greater detail by Holcombe in U.S. Patent No. 3,900, 728, patented August 19,1975.

The invention in one embodiment also provides a lightstick and an attached actuating device of the kind described in a container which is

especially adapted for storage of the lightstick with the actuating device attached until the lightstick is needed, and is adapted for reading access of the same to the user when needed. The container is further adapted with means for use of the container in combination with the lightstick for display of the light to advantage in several kinds of emergency situations.

The container is a box with a hinged lid, and it can be used with the lid closed to safely and compactly contain the lightstick. The closed container encloses the lightstick and is of material strong enought to prevent accidental activation of the lightstick during storage, as by accidental bending or impact, or the like. The container lid is adapted with releasable latch means for holding the hinged lid of the box closed during storage, but the latch means can be easily released by hand operation to open the container. On the inside of the container, releasable storage clamping means are provided for holding the lightstick at a fixed storage position inside the container, and winding pegs are provided by which one end of a lanyard can be attached to the container and the lanyard can be wound on the pegs for storage of the lanyard in the container. Other releasable clamping means are provided inside the box for holding the lightstick at a display position in which the lightstick cooperates with the container to hold open the lid of the container while the light is displayed. In some preferred embodiments, all, or an appropriate portion of the inner surfaces of the container are made reflective to enhance display of the light when the lightstick is mounted at the display position in the container. In some preferred embodiments the container is adapted on its outer surface with means for attaching the container to a person's clothing or the like for convenience in carrying or displaying the light package.

The lightstick as used in accordance with the this embodiment of the invention has an attached actuating device. This device provides a fulcrum against which the lightstick can be manually bent by squeezing the lightstick towards the lever on the device. This actuation can be conveniently performed by squeezing the assembly in one hand. As shown in Figure 2 the actuating device comprises a steel handle (6) attached to the outer tube by a steel band (7) which fits snugly around the outer tube (2) of the lightstick. The band (7) is bolted to the handle through an extension of the band which extends inside the handle. A straight length (8) of the handle is held tangent longitudinally against the outer wall of the lightstick. The fulcrum (9) of the handle is at the end of the straight length nearer to the center of the lightstick than the band. The lever arm (10) of the handle extends from the band at an angle diverging from the straight length and extends beyond the fulcrum.

A lanyard (11) is provided by which the lightstick is secured to the container in order to prevent accidental loss of the lightstick.

The lanyard may be of any length; a convenient length is about two to three feet. A small hole (12) is provided in the actuating handle, through which the lanyard is tied to attach one end of the lanyard to the lightstick and actuating assembly. The other end of the lanyard is secured to the inside of the container.

Referring now to Figure 3, the container (13) comprises a box (14) with a lid (15) hinged thereto by a hinge (16) that permits opening and closing the lid on the hinge through 180° between the closed position and the fully open position. At the fully open position shown in Figure 3, the flat top of the lid and the flat bottom of the box preferably lie approximately in the same plane. In the embodiment shown, both the lid and box have front, side and rear walls (17), joined at the corners to enclose the inside of the container. The walls of the lid and box are of approximately equal depth and the hinge joins the edges of the rear walls of both the lid and the box. Opposite the hinge at the front container the lid and box are fitted at the center of the front walls with a latch and notch set (18) which will engage to hold the lid shut when the box is closed. The latch and notch set are preferably operable by simple finger operations to fasten or release their engagement.

Inside the box are several fittings for clamping the lightstick in storage and display positions and for securing the lanyard and winding it for storage. In the embodiment shown in Figure 3, the entire container and its fittings are integrated as a single polypropylene injection molded unit. Extending inward from the flat bottom of the box are integrally molded lugs and pins which serve various storage functions. Along the rear wall of the box are two spaced apart lugs (19) which cooperate with an opposed third lug (20) spaced inwardly from the back wall by the diameter of the lightstick. The third lug is offset with respect to the two rear wall lugs to cooperatively hold the lightstick against the other two lugs when the lightstick is pressed between the three lugs. At the upper end of each of the three lugs a lip (21) extends inwardly towards the lightstick to hold the lightstick down. The three lugs are resilient enough to permit the upper ends of opposed lugs to spread slightly to permit the widest diameter of the lightstick to be pressed through the lips, but are strong enough to hold the lightstick in place between the lugs. This is the storage position for the lightstick and the box and lid are wide enough from front to rear to contain the lightstick in storage position with its attached handle inside the closed box. At one end inside the box, two sets of directly opposed lugs (22) are provided for clamping the lightstick in its display position. These are used only when the lid is fully opened and the lightstick is clamped with its length extending cross-wise from the box onto the lid. To accommodate the lightstick in this display position, portions of the rear walls of the lid and box are cut out to form an aperture (23) which permits the lightstick to lie inside the box and opened lid, extended across the aperture parallel

to the plane of the bottom of the box. In the embodiment shown in the drawings, there are two sets of opposed clamping lugs (22) extending upward from the bottom of the box. The two lugs in each set are spaced apart by the diameter of the lightstick. One set of two opposed lugs stands in the plane of the rear wall of the box. One lug of this set stands at each side of the aperture (23) that has been cut away from the rear wall of the box to make way for the lightstick to extend across the walls when the lid is open. The second set of opposed lugs stands inside the box towards the longitudinal center line of the box and holds the lightstick in position at right angles to that line. The two sets of opposed lugs (22) are spaced apart points along its length. The two lugs in each set are spaced apart by the width of the outer tube and the lugs are equipped with inwardly extending lips for retaining the lightstick between the lugs until it is pulled out forcibly to pass through the lips by resilient yielding of the lugs.

On an outside surface of the container, in our most preferred embodiments, we provide an attached metal clip (25) which can be used for attachment of the container to an article of clothing such as a person's waist belt or coat pocket, or the like. This permits one to carry the container either closed or at a visible position for displaying the light with the container opened and the lightstick in its display position. When so displayed, the lightstick as held by the retaining lugs extends across the back walls from the box into the open lid and cooperates to retain the lid at its open position. In a preferred embodiment the inside surface of the box and lid is at least partly covered with reflective material, e.g. bright metal foil, which serves as a reflector behind the lightstick at display position to intensify the radiation outward from the container.

The container can be stored with the lightstick inside at the storage position, with the handle attached to the lightstick and the lanyard secured to the handle and to one of the winding posts on which it is wound. The latch and notch set holds the lid closed. The box can be stored at any convenient place. The container shown in the drawings, when closed is about 2-3/4" wide, 5-3/4" long and 1" deep. This size box can be conveniently stored in the pocket of the life jacket, or several containers may be stored in compartments on a life raft, etc. The polyolefin latch can be released from its notch by forcing the clasp outward. There is sufficient resiliency of the polyolefin to hold the clasp in the notch but it will yield to the manual force of one finger to pull the latch from the notch. The lid is opened on its hinge and the lightstick is pulled away from its storage lugs. To avoid losing the container if it were dropped, one may attach the box to an article of clothing. One may unwind the lanyard, actuate the light by squeezing the lightstick towards the handle to bend and break the inner vials. It is preferred to shake the tube enough to mix the chemicals inside. The light produced by the chemiluminescent reaction will begin almost immediately. For signalling, the light can be spun on the lanyard, to make the appearance of a circle of light. The lightstick can be clamped in the display position and used as a signal or to provide light for working, or the like. The open container with the activated lightstick clamped at the display position can be attached to the person or to a gunwale or the like to serve as a lantern.

Another embodiment of the invention provides as part of chemiluminescent lighting device, a molded outer tube, lever and fulcrum all comprised as integral parts of a single injection molded unit which accomplishes the same object as the several members of the prior art device described above by simpler means.

This embodiment will be described in more detail by reference to the drawing. In the drawings.

Figure 7 is an isometric view of single, integrally molded unit comprising a tube, a lever and a fulcrum; this unit is useful as an improved element of a chemiluminescent device.

Figure 8 is a side elevation of the molded unit shown in Figure 7, with a portion of the lever cut away to show a cross section of the lever.

Figure 9 is front elevation view showing a complete chemiluminescent device embodying the invention.

Referring to Figure 7, an outer tube 101 comprises a hollow cylinder, closed at its lower end by rounding the cylinder walls to a center point. Tube 101 is open at its opposite end. In a typical embodiment we employ a tube about 5 inches long, about 0.717 inch outer diameter and with tube wall thickness about 0.120 inch. This outer tube 101 is formed by injection molding with a suitable molding composition to provide a semi rigid translucent tube that is flexible enough to permit some resilient bending of the tube, sufficient for actuation of the tube to break an inner glass vial within the tube. A lever 111, molded of the same molding material used for making the outer tube, is joined to and extends outward from the walls of the tube as a member of the single molded unit which comprises the tube, lever and fulcrum. Preferably the lever is joined to the tube wall nearer to one end of the tube, and preferably nearer to the open end of the tube as shown in Figure 7. From this point the lever extends in the direction of the other end of the tube along a line which lies in a plane with the axis of the tube. However, the lever diverges at an angle from the tube axis as the lever extends away from its joint with the tube wall. At a point on the lever between its joined end and its free end, the lever is fitted with a fulcrum 121 which is another integral member of the same molded unit. The fulcrum extends from the lever towards a point on the tube wall at or near the center of the length of the tube. It is not necessary that the bearing edge of the fulcrum must be joined to the tube wall, but it may be joined there if desired. In our most preferred embodiment, the fulcrum 121 is not joined directly to the tube wall.

It is necessary that the lever and fulcrum be sufficiently rigid so that when the free ends of the tube and lever are pressed towards each other, the tube will bend against the fulcrum. In our most preferred embodiment the lever is formed with a cross section resembling that of an I-beam, as shown in Figure 8, having a flat web 131 of the molding material lying in a plane with the tube axis and having flanges 141 at the edges of the web 131. The flanges extend outward at right angles from the edge of the web where the web is joined integrally to the flange at the center of the flange. Similarly, a triangular fulcrum 121 is made with the same web-and-flange construction to provide rigidity. In the embodiment shown in the drawings the flanges along the edges of the fulcrum are extended across the lever 111 forming a closed triangle with the outer flange 141 of the lever. This flanged triangle interrupts the inner flange on the lever. The web and flanges of the lever emerge directly from the tube wall to form the length of the lever. At the outer free end of the lever, the inner and outer flanges of the lever are joined around the end of the web.

In our most preferred embodiment the thickness of the web 131 and also of the flanges 141 is nominally 0.125 inch and the flange width is 0.717 inch, the same as the tube diameter. The width of the web between the flanges is tapered towards the free end. The width of the web is about 0.5 inch at the joint of the tube and lever; the web tapers to a narrow rounded end at the extreme end of the lever. In the embodiment shown in the drawing, the web and flanges forming the lever emerge from the tube walls and extend at right angles to the tube axis for a short distance and then turn to define the selected angle of divergence between the axis of the tube and the extended lever. In accordance with the construction described, the single unit of injection-molded polyethylene molding resin comprises a translucent tube, a lever and a fulcrum. The tube can be bent against the fulcrum to activate the chemical light. The construction shown and described is designed for operation by a person using one hand to squeeze the free end of the tube against the lever.

Referring now to Figure 9, the complete device comprises the single molded unit described above, and the components of the chemiluminescent mixture as described above sealed inside the tube with frangible separating means which can be broken by bending the tube.

Claims

1. A chemical lightstick comprising a flexible translucent outer tube and contained therein first and second frangible vials, the first vial containing a solution of a bis(carbalkoxy-trichlorophenyl)oxalate component wherein alkoxy has 1 to 8 carbon atoms in a suitable diluent and a 9,10-bis(phenylethynyl)anthracene component in a suitable diluent, said second vial containing a peroxide, and the outer tube containing outside said vials a diluent for said components which may also contain an additional amount of said anthracene component.

2. A lightstick according to Claim 1, wherein one of said glass vials is contained inside the other with the respective components separated within each vial.

3. A lightstick according to Claim 1 or Claim 2, wherein said first vial contains a solution of a bis(6-carboalkoxy-2,4,5-trichlorophenyl) oxalate wherein the alkoxy group has 5 to 8 carbon atoms, and 9,10-bis(phenylethynyl)anthracene or a halo-substituted 9,10-bis(phenylethynyl)anthracene in a diluent; said second vial contains a solution of hydrogen peroxide and an accelerator in a diluent; and said outer tube contains a solution of 9,10-bis(phenylethynyl)anthracene or a halo-substituted 9,10-bis(phenylethynyl)anthracene in a diluent.

4. A lightstick according to Claim 3, wherein said first vial contains a solution of bis(6-carbopentoxy-2,4,5-trichlorophenyl)-oxalate and 9,10-bis(phenylethynyl)-anthracene or monochloro-9,10-bis(phenylethynyl)anthracene in dibutyl phthalate; said second vial contains a solution of hydrogen peroxide and sodium salicylate in a mixture of dimethylphthalate and tertiary butanol; and said outer tube contains a solution of 9,10-bis(phenylethynyl)-anthracene or monochloro-9,10-bis(phenylethynyl)-anthracene in dibutyl phthalate.

5. A lightstick according to any preceding Claim, wherein the concentration of the oxalate component in said first vial is from 0.025M to 3.65M, and the total concentration of the 9,10-bis(phenylethynyl)anthracene component in said second vial and, if present, in said outer tube is from 0.0005M to 0.06M.

6. A lightstick according to Claim 5, wherein the concentration of the oxalate component in said first vial is from 0.07M to 0.7M, and the total concentration of the 9,10-bis(phenylethynyl)anthracene component in said second vial and, if present, in said outer tube is from 0.002M to 0.02M.

7. A lightstick according to any preceding claim, wherein the ratio of the total volume of the liquids in said first vial and in said outer tube to the volume of the liquid in said second vial is from 2.5—5.5:1.

8. A lightstick according to Claim 7, wherein said ratio is from 4.0—5.0:1.

9. A lightstick according to any preceding Claim, wherein the total volume of the liquids in said first and second vials and said outer tube is such that upon activation of the lightstick the initial concentration of said bis(carbalkoxy-trichlorophenyl)oxalate component in the resulting chemiluminescent mixture ranges from 0.05M to 0.09M.

10. A lightstick according to any preceding Claim, further comprising a lever attached at one of its ends to said outer tube near one end of said tube, and extending along a line in a plane with the centerline of said tube and diverging at an

acute angle from the tube wall, a fulcrum joined to said lever at a point between the ends of said lever and extending from said lever towards a contact point on the outer wall of said tube between the tube ends, said tube being flexible by bending said tube against said fulcrum when the free ends of said tube and lever are pressed together.

11. A lightstick according to Claim 10, wherein said lever is a metal lever attached by a metal band to said tube.

12. A lightstick according to Claim 10, wherein said lever is of the same material as said tube and is integrally molded to said tube wall at the point of said tube and lever.

13. An emergency lighting device comprising a lightstick according to any one of Claims 10 to 12, a container defining a storage space for storage at a storage position therein of said lightstick, said container comprising a lid operable on a hinge between an open position for access to remove said lightstick from said storage space and a closed lid position for enclosing the same within said storage space;

said lid being rotatable on said hinge through 180 degrees from its closed lid position to an open display position, and clamping means inside said box for releasably clamping said lightstick at a display position which is different from said storage position, in which display position said lightstick cooperates with said clamping means to hold said lid at said open display position for display of the lightstick.

14. An emergency lighting device according to claim 13, said container being a single polyolefin molding having an integral molded polyolefin hinge joining said lid to the said box, integral molded polyolefin latching means for releasably holding said lid at its closed position, integral molded polyolefin retaining lugs inside said container for releasably retaining said lightstick at its storage position within storage space and integrally molded clamping means for releasably clamping said lightstick at its display position.

15. A chemiluminescent lightstick, according to Claim 1 and substantially as described in any one of the Examples herein.

16. A chemiluminescent lightstick, according to Claim 1 and substantially as hereinbefore described with reference to Figures 1 to 6 or to Figures 7 to 9 of the accompanying drawings.

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